PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A61J 3/07 — A1

(11) International Publication Number: WO 97/35537

(43) International Publication Date: 2 October 1997 (02.10.97)

(21) International Application Number: PCT/GB97/00838

(22) International Filing Date: 25 March 1997 (25.03.97)

(30) Priority Data:
9606371.4 26 March 1996 (26.03.96) GB

(71) Applicant *(for all designated States except US)*: BIO-PROGRESS TECHNOLOGY LIMITED [GB/GB]; St. John's Innovation Centre, Cowley Road, Cambridge CB4 4WS (GB).

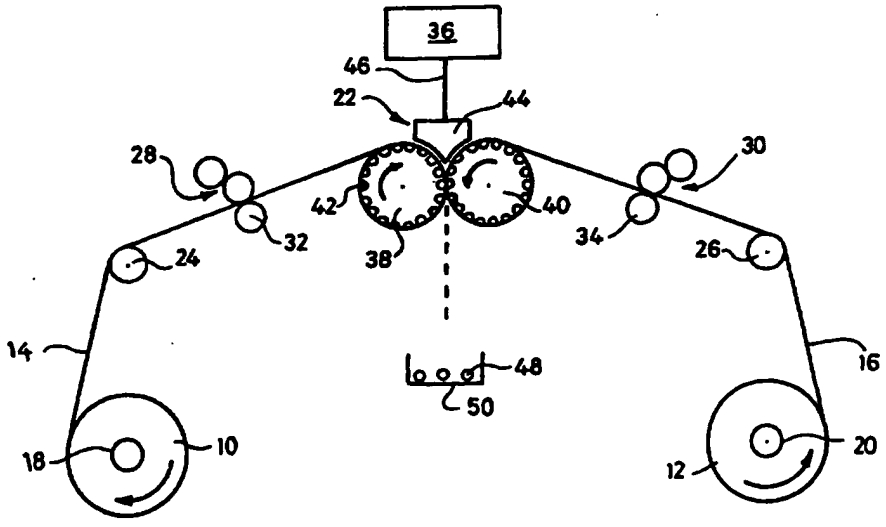
(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: BROWN, Malcolm, David [GB/GB]; 87 The Lammas, Mundford, Norfolk IP26 5DS (GB).

(74) Agent: KEITH W. NASH & CO.; 90-92 Regent Street, Cambridge CB2 1DP (GB).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: IMPROVEMENTS IN OR RELATING TO ENCAPSULATION



(57) Abstract

A method of encapsulation is characterised by supplying to an encapsulation unit (22) two films (14, 16) of like material capable of deforming elastically at least when partially solvated, and applying solvent to at least one of the films prior to encapsulation to cause partial solvation of the material surface, such that the partially solvated surface can adhere to and seal with the film material. In the encapsulation unit, the substance to be encapsulated e.g. a cosmetic oil or vitamin preparation is supplied between the films, the films are formed, typically by a moulding process, into suitably shaped capsule portions which can adhere to each other as a result of the adhesive action of the partially solvated surface(s), and which seal together encapsulating the supplied substance, forming a capsule. The invention enables encapsulation using materials other than gelatin, such as polyvinyl alcohol. Also disclosed is encapsulation apparatus and the resulting capsules.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

Title: Improvements in or relating to Encapsulation

Field of Invention

This invention concerns encapsulation and relates to a method of encapsulation, encapsulation apparatus and the resulting capsules.

Background to the Invention

The provision of water soluble and digestible capsules containing pharmaceutical or cosmetic preparations is well established. Typically oils are encapsulated in gelatin shells designed to release their contents when subjected to immersion in water or exposure to digestive juices. These oils include dietary enhancement substances or, in the case of cosmetic preparations, fragrant oils for release into bath water. A substantial industry has been built up around this principle, based primarily on the use of gelatin for the capsule shells. This gelatin is derived from the bones and skins of animals.

With concern for the environment and animal welfare and fear of animal related diseases such as Bovine Spongiform Encephalopathy (BSE) increasing, the number of individuals adopting a serious stance on the use of animals and animal-derived products in food substances and cosmetic applications has risen dramatically. As a result, the sales of such gelatin capsules are very limited among such individuals. There exists therefore the need for the provision of a suitable substitute for gelatin in order to provide water soluble or digestible capsules which are not derived from animals. Whilst this is a desirable aim, few materials lend themselves to such use and the machinery currently creating such capsules has been specifically designed to suit the properties of gelatin. As a result, a change in material for the capsule shell requires a redesign of the machinery if it is to have the capability of efficiently producing capsules from the replacement material. It is a change in material and the commensurate machine requirements needed to enable successful processing which this invention addresses.

Summary of the Invention

In one aspect, the present invention provides a method of encapsulation, characterised by supplying to an encapsulation unit two films of like material capable of deforming elastically at least when partially solvated, and applying solvent to at least one of the films prior to encapsulation to cause partial solvation of the material surface, such that the partially solvated surface can adhere to and seal with the film material.

In the encapsulation unit, the substance to be encapsulated is supplied between the films, the films are formed, typically by a moulding process, into suitably shaped capsule portions which can adhere to each other as a result of the adhesive action of the partially solvated surface(s), and which seal together encapsulating the supplied substance, forming a capsule.

In a further aspect, the invention provides a method of encapsulation, comprising supplying two films of like material capable of deforming elastically at least when partially solvated; applying solvent to at least one of the films to cause partial solvation of the material surface; supplying substance to be encapsulated between the films; forming the films into suitably shaped capsule portions which can adhere to each other as a result of the adhesive action of the partially solvated surface(s); and sealing the capsule portions together, encapsulating the supplied substance, to form a capsule.

Conventional gelatin encapsulation relies upon heat as the mechanism for sealing the two portions of the shell together to enclose the contents. The capsules made by this invention do not use heat as the primary means of securing the two portions of the capsule together, but instead make use of the adhesive effects manifested when suitable films are partially solvated at their surface.

The films may be of a range of different materials. Suitable materials soluble in water (hot or cold) include polyvinyl alcohol (PVA), alginate, hydroxypropyl methyl cellulose and polyethylene oxide. In this case it is simply necessary to apply water at a suitable temperature to the film or films to cause partial solvation. The resulting capsules release

their contents when immersed in water or exposed to digestive juices and thus lend themselves to such uses as the release of fragrant oil in a bath or the release of dietary supplements after ingestion. If the material is only soluble in hot water then it is necessary to apply water at appropriately elevated temperatures, but the partial solvation and the subsequent adhesive effects are still effective to seal the capsule.

Non-water soluble film materials may also be used, such as polycaprolactone and gelatinized starch based materials. In this case it is necessary to apply a suitable solvent such as N-methyl pyrrolidone rather than water to at least one film surface to induce partial solvation. The partial solvation of such films causes them to soften, enabling them to take up the internal dimensions of a mould used to create a capsule. Capsules made from films which are biodegradable but not water soluble release their contents as a result of microbial action instead of immersion in water, and can find use in agricultural and industrial applications.

The currently preferred film material is PVA, preferably plasticised with glycerin. Suitable films are commercially available in a range of different grades, types and thicknesses. An appropriate film can be readily selected having regard to the intended use, capsule contents and desired capsule properties. For example, PVA film is available in thicknesses ranging between 20 and 1000 microns. For cosmetic applications, good results have been obtained with 80 micron PVA film, eg Hi-Selon (Hi-Selon is a Trade Mark) cold water soluble PVA B9, obtainable from British Traders and Shippers, 429-431 Rainham Road South, Dagenham, Essex.

It is preferred to use film material that becomes more flexible when in partially solvated conditions as this assists capsule formation. PVA has this property.

Instead of using pre-formed films, the films may be formed during the encapsulation method, eg by being cast from solution.

In practising the invention it is appropriate to use two films of like material. The films should be chemically alike but need not be identical in terms of factors such as grade,

thickness etc.

The solvent is selected having regard to the film material, and is conveniently water in the case of water soluble materials. The solvent should be applied in an appropriate amount, either in isolation or as part of a formulation containing materials such as thickening and/or wetting agents, to cause a suitable degree of partial solvation of the film material surface: this can be readily determined by experiment.

The solvent is preferably applied just prior to encapsulation at an appropriate location to obtain optimum speed of capsule production.

The solvent can be applied in a variety of different ways, including by atomisation such as in the form of a spray or jet, by dipping, electrostatic coating, roller, air knife or Meyer bar, or with a sponge. The currently preferred technique is by means of a gravure or flexo printing process as this enables ready control and regulation of the amount and uniformity of solvent application.

Solvent may be applied to one or both films as appropriate.

A vacuum is conveniently applied during capsule portion formation to assist deformation of the film material.

The invention may be used to encapsulate a wide range of substance in the form of solids, liquids or gases. The invention may, for example, be used to encapsulate all of the substances currently encapsulated in gelatin, such as drugs, vitamins, powders, oils, cosmetic preparations, drug delivery systems, paint etc. A typical cosmetic application is encapsulation of bath oils to produce capsules intended to be used in the bath, where the capsule shell dissolves releasing the oil into the bath water.

The capsules may have a variety of different sizes and shapes, usually determined by the shape of the mould employed. Typically the capsules are spherical or oval, but more elaborate forms eg based on fruit, animal or abstract shapes may be produced, usually for

cosmetic applications.

In a further aspect the invention provides encapsulation apparatus comprising means for supplying two films of material to an encapsulation unit; an encapsulation unit; and means for supplying a solvent for the film material to at least one of the films upstream of the encapsulation unit.

The encapsulation unit may be based on those used in conventional apparatus currently used for gelatin encapsulation. In typical conventional apparatus, two separate ribbons of gelatin film are first produced by pouring heated liquid gelatin at a controlled rate onto the peripheral faces of two cylinders each rotating about a horizontal axis. The liquid gelatin cools on the cylinders and forms two ribbons which are fed from opposed sides to an encapsulation unit.

The encapsulation unit typically comprises a pair of similar moulding drums. The outer cylindrical face of each drum is formed with a plurality of indentations of desired form, eg hemispherical, arranged in a series of axially extending rows with, say, 5 or 6 indentations in each row. The drums are supported in side by side relationship, with a small gap there between, and are arranged for coordinated rotation in opposed directions (the left hand drum clockwise, and the right hand drum anticlockwise). A similar arrangement may be used in the present invention. Means for applying a vacuum inside the drums are conveniently included, to help pull the partially solvated films into the indentations and so assist capsule portion formation.

The encapsulation unit typically also comprises a reservoir of the substance to be encapsulated, eg bath oil, and an associated supply arrangement adapted simultaneously to supply a plurality of metered doses (one for each indentation in a row on the moulding drums) of the substance to the moulding drums at predefined time intervals. The arrangement may employ syringe pumps or the like. Again, a similar arrangement may be used in the present invention.

The metered doses are initially supplied to a heated injection segment located above the

nip between the moulding drums, and including a row of a plurality of injectors aligned with the rows of indentations in the drums. A similar arrangement may again be used in the present invention although there is no need for the injection segment to be heated.

In use in conventional encapsulation, two gelatin ribbons are formed and fed over appropriate guide rollers etc to pass below the injection segment and into the nip between the counter-rotating rollers. Metered doses of the substance to be encapsulated are injected into the nip in synchronism with the drum rotation. The heating segment also acts to heat the gelatin films, which has the effect of making the films capable of sealing to each other and also makes the films more elastic. As the doses of substance are injected between the heated films, the films deform to line the indentations, forming series of pairs of opposed capsule halves containing the substance. The pairs of capsule halves are brought together, sealed and cut from the gelatin ribbons on continued rotation of the drums, thus forming capsules containing the substance. A typical production rate is one row of capsules every 2 seconds. Instead of cutting the capsules from the ribbons, they may be left integral with the ribbons. The resulting capsules are collected below. The capsules are then typically tumbled in a hot air dryer and then kept in a controlled humidity environment for about 2 days to stabilise the capsules. The capsules are then ready for use or sale.

As noted above, the present invention may use an encapsulation unit generally as described. It is not necessary for the injection segment to be heated, as the present invention does not rely on heating for sealing, as in the prior art, so processing costs may be reduced somewhat and faster processing may be possible. However, the films of the present invention may optionally be heated: in some cases this may enhance film elasticity and sealing.

Conventional encapsulation apparatus would, of course, also need modification by removal of the gelatin ribbon formation equipment and substitution of equipment for supplying (and possibly also forming) the films of material used in the present invention. In a simple case this could just be a pair of spindles each for receiving a roll of the film, to be fed to the encapsulation unit in known manner.

A further necessary modification is addition of mean for applying solvent to one or both of the films, preferably located just upstream of the encapsulation unit. As noted above these means could be a spray or jet arrangement, a bath for dipping, an electrostatic coating unit, a roller, an air knife, a Meyer bar, a sponge etc. Preferably, however, a gravure or flexo printing unit is used.

Means for applying a vacuum within the moulding drums are conveniently also incorporated.

The invention also covers capsules formed in accordance with a method or by use of apparatus in accordance with the invention.

The invention also includes within its scope a capsule having a shell comprising material capable of adhering to and sealing with itself when in partially solvated condition.

In a preferred aspect the invention covers a capsule having a shell comprising polyvinyl alcohol.

The invention will further be described, by way of illustration, in the following Example and with reference to the accompanying drawing, in which:

Figure 1 is a schematic illustration of one embodiment of apparatus in accordance with the invention.

Detailed Description of the Embodiment

The apparatus illustrated in Figure 1 comprises two rolls 10, 12 of film 14, 16 of like material rotatably supported on spindles 18, 20, with associated means (not shown) for feeding film from the rolls to an encapsulation unit 22. The films first pass over respective support rollers 24, 26 and then through respective flexographic printing units 28, 30 with associated backing rollers 32, 34 for supply to a surface of the film, in an adjustable manner, of accurately metered quantities of solvent for the film material. In an

experimental apparatus, laboratory scale narrow flexographic heads from RK Print Coat Instruments Limited, Litlington, Royston, U.K. were used for this purpose.

The encapsulation unit 22 is based on the encapsulation unit of conventional apparatus, as discussed above, and comprises a reservoir containing the substance to be encapsulated and an associated supply arrangement for supplying metered doses of the substance. The reservoir and supply arrangement are represented schematically at 36.

The encapsulation unit further comprises a pair of similar moulding drums 38, 40. The outer cylindrical face of each drum is formed with a plurality of hemispherical indentations 42 arranged in a series of axially extending rows with 6 indentations in each row. Vacuum means (not shown) may optionally be included for applying a vacuum inside the drums to assist deformation of the film material. The drums are supported in side by side relationship with a small gap therebetween, and are arranged for coordinated rotation in opposed directions (the left hand drum 38 clockwise, and the right hand drum 40 anticlockwise). An injection segment 44 is located above the nip between the moulding drums to receive substance from reservoir and supply arrangement 36, as illustrated schematically by line 46. Injection segment 44 includes an array of 6 injectors (not shown) aligned with the rows of indentations in the drums.

In use, film 14, 16 is supplied at an appropriate rate to the encapsulation unit 22, passing over support rollers 24, 26 and through printing units 28, 30 where solvent is applied to the film surface in appropriate amount. The films then pass below the injection segment 44 and into the nip between drums 38, 40 which are counter-rotating at an appropriate speed. Metered doses of the substance to be encapsulated are injected into the nip from injection segment 44 in synchronism with the drum rotation. As the doses of substance are injected between the films, the films deform to line the indentations 42 of one row in each of the drums, possibly assisted by application of a vacuum, forming a series of 6 pairs of opposed capsule halves containing the substance. On continued rotation of the drums the pairs of capsule halves are brought together and seal because of the adhesive effect caused by partial solvation of the film surface, producing a row of surface-containing capsules which are cut from the films. One row of 6 capsules is produced

approximately every 2 seconds. The resulting capsules 48 are collected in a tray 50, and the waste film remaining is disposed of. The capsules are dried and stabilised in generally conventional manner.

Example

Using the apparatus of Figure 1 encapsulation of a typical bath oil cosmetic product was carried out using Hi-Selon cold water soluble plasticised polyvinyl alcohol (B9) film, 80 micron thick, with partial solvation carried out by application of water. This resulted in production of good quality capsules, suitable for cosmetic use.

CLAIMS

1. A method of encapsulation, characterised by supplying to an encapsulation unit two films of like material capable of deforming elastically at least when partially solvated, and applying solvent to at least on of the films prior to encapsulation to cause partial solvation of the material surface, such that the partially solvated surface can adhere to and seal with the film material.

2. A method of encapsulation, comprising supplying two films of like material capable of deforming elastically at least when partially solvated; applying solvent to at least one of the films to cause partial solvation of the material surface; supplying substance to be encapsulated between the films; forming the films into suitably shaped capsule portions which can adhere to each other as a result of the adhesive action of the partially solvated surface(s); and sealing the capsule portions together, encapsulating the supplied substance, to form a capsule.

3. A method according to claim 2, wherein a vacuum is applied during capsule portion formation to assist deformation of the film material.

4. A method according to claim 1, 2 or 3, wherein the film material is selected from polyvinyl alcohol, alginate, hydroxypropyl methyl cellulose, polyethylene oxide, polycaprolactone and gelatinized starch based materials.

5. A method according to claim 4, wherein the film material is polyvinyl alcohol and the solvent is water.

6. A method according to any one of the preceding claims, wherein the film material becomes more flexible on partial solvation.

7. A method according to any one of the preceding claims, wherein the solvent is applied just prior to encapsulation.

8. A method according to any one of the preceding claims, wherein the solvent applied by means of a gravure or flexo printing process.

9. Encapsulation apparatus comprising means for supplying two films of material to an encapsulation unit; an encapsulation unit; and means for supplying a solvent for the film material to at least one of the films upstream of the encapsulation unit.

10. Apparatus according to claim 9, wherein the encapsulation unit comprises a pair of counter-rotating moulding drums, and an associated arrangement for coordinated supply of substance to be encapsulated.

11. Apparatus according to claim 10, including means for applying a vacuum inside the moulding drums.

12. A capsule having a shell comprising material capable of adhering to and sealing with itself when in partially solvated condition.

13. A capsule having a shell comprising polyvinyl alcohol.

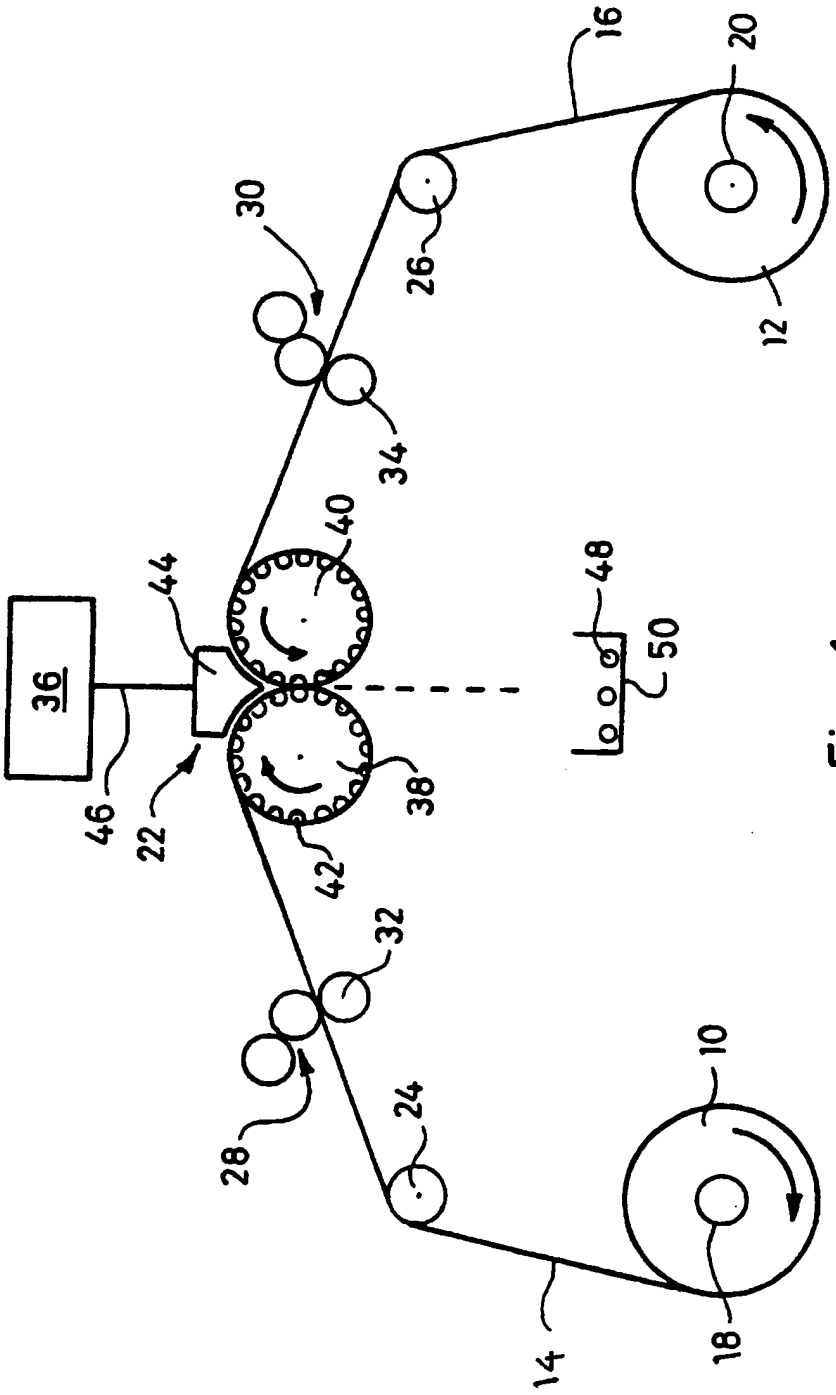


Fig. 1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/00838

A. CLASSIFICATI N OF SUBJECT MATTER
IPC 6 A61J3/07

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61J B65B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 91 04017 A (BANNER GELATIN PRODUCTS CORP.) 4 April 1991 see page 9, line 40 - page 11, line 34; figure 13 see page 23, line 8 - line 15	1-13
Y	US 4 154 636 A (FREUND INDUSTRIAL CO.LTD.) 15 May 1979 see the whole document	1-13
A	GB 758 642 A (FISHER) 10 October 1956 see page 1, line 9 - line 38; figure 1	1
A	US 2 288 327 A (SCHERER) 30 June 1942 see page 1, left-hand column, line 5 - line 30; figures	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
24 July 1997	29. 07. 97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Baert, F

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 97/00838

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9104017 A	04-04-91	US 5146730 A	15-09-92
		AT 146070 T	15-12-96
		AU 669616 B	13-06-96
		AU 6195894 A	07-07-94
		AU 648270 B	21-04-94
		AU 6449090 A	18-04-91
		CA 2003529 A	20-03-91
		DE 69029397 D	23-01-97
		DE 69029397 T	10-04-97
		EP 0493489 A	08-07-92
		ES 2097762 T	16-04-97
		JP 5500514 T	04-02-93
		US 5459983 A	24-10-95
US 4154636 A	15-05-79	JP 1173571 C	28-10-83
		JP 52028926 A	04-03-77
		JP 57024325 B	24-05-82
		DE 2638315 A	03-03-77
GB 758642 A		NONE	
US 2288327 A	30-06-42	NONE	